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Abstract: Geographic Information Systems will be expected in the future to evolve to integrate social simulations or ecological processes inside complex systems of active and interactive entities. In a more practical aspect, GIS has now to evolve to manage updating. We will explain how the updating processes can be described as an evolution processus for GIS and make them transform from complicated systems to complex systems. This evolution processus is decomposed in an influence table which corresponds to elementary canonical operations. The application of these elementary operations as basic rules for each step of the GIS evolution over the connection graph which links the Geographical Database objects will create a dynamic interaction network which charaterizes the complexity. In addition to these updating elementary operations, we verify, during the processus, the maintenancy of the whole geographical database using a constraint-based system. Our goal is to make the updating satisfying the global consistent property which emerges from the computation over the whole evolutive system. In this paper, we will give the whole processus description which leads to obtain this emergent property of consistence from a dynamic propagation processus which allows to obtain the global consistence from a local satisfaction property.

Keywords: geographical database; complex systems; spatial constraints; evolution; emergence.

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1 INTRODUCTION

The development of huge networks of communications allows today to share a great amount of data. With the use of these new technologies, the need of informations becomes important. The easy sharing of data all over the world makes that interactions processes, at many different scales, are needed to analyse the present world in all its complexity. We need new models based on the basis of this complexity: interactions-based and multi-scales-based (3).

The new technologies and especially the satellites give a great amount of data concerning geographical informations. The important improvement of computer sciences as the science of modelization and conceptualisation and the increasing performance of computers and networks, lead to buid efficient Geographic Information Systems (GIS). These GIS allow to represent heterogeneous informations which are strongly linked and stored in Geographical Data Bases (GDB). These GDB based on vector representation are generally composed of layered classes of objects. Each layer is associated to a semantic thematic like road traffic, fluvial tracing, buildings, vegetation, etc.

Moreover, the new challenges in geography concerns also the analysis and the understanding of the interactions all over the world about social, geopolitic and ecological aspects. These challenges need to develop and manage suitable conceptual and generic models. Complex modelling to describe complex processus over the structured networks of GDB, is an efficient way to answer to these challenges. On the practical aspect, GIS development is concerned today with one of these complex processus over GDB which is the updating processing for GIS (4).

The constant evolution of the real world which must be represented in the geographical data bases induces the need to regularly update the Data Base. The knowledge of updating is generally associated to the concerned semantic layer. Each semantic layer has its own updating frequency which can differ from one layer to another. This heterogeneity can be the cause of some problems on the consistency maintenance of the whole GDB. On the figure 1, we describe the updating generated by a new road arrangement. The first part of this figure shows the initial map configuration. The second part shows a first uncorrect updating without checking the whole consistence, generating superposition of a new road portion over existing buildings (left bottom of the road crossing). The last part shows a correct updating after the propagation of some topological constraints between the layer of the road tracing and of the layer of the buildings position.

In this paper, we propose a solution for the Geographical Data Base updating problem with maintaining its consistency. First, we will develop in the section 2, how Geographic Information Systems is expected to be transformed in Complex Geographic Information Systems by the application of complex processus over the geographical data network. Section 3 deals with the proposed formalism of evolutive GIS as one of these complex GIS. We explain where the complexity appears in the formalism to transform a complicated system in a complex system. Section 4 describes how we will build a dynamical interaction network from the application of influence tables over GDB. We will explain how the processus described can be compared with cellular automata. In section 5, we present the effective algorithm of updating based on a propagation processus and we focus on the major problem of updating which concerns the consistency maintenance. In Section 6,

Figure 1: Updating within consistency maintenance

we present the emergent property of the global consistency maintenance from the local consistency maintenance. Section 7 presents implementations and experiments and we conclude in section 8.

2 FROM GIS TO COMPLEX GIS

A Geographic Information System (GIS) is a computer-based tool using geographical objects. A GIS is composed of a Geographical Data Base (GDB) with applicative operators which allow it to get, to stock, to verify, to manipulate, to analyze and to represent the spatial data of the GDB.

The originality of Geographical Data Base from ordinary Data Base is the use of spacial data (11). the latter may be represented in a Geographical Data Base with two aspects: in raster mode or in vector mode. The raster mode is based on a pixels grid representation. The vector mode manipulates geographical features. In the following, we will focus our attention on the vector mode representation where each feature is represented by an object. Each object has a semantic part describing the nature of a feature which it represents and a geometric part describing its shape and its localisation. The position of the objects the ones compared with the others is an important information which is usually represented in the Geographical Data Base.

So, in Geographical Data Bases, geographical information is often represented with three levels: geometric, semantic and topological. From each level, we can define relations between objects that have to be linked corresponding to the specific level.

At the semantic level, a Geographical Data Base is often structured with layers. Layers are generally defined concerning a specific thematic like road traffic, fluvial tracing, building or vegetation. Generally, objects of a same layer have the same geometric representation and share the same topological properties inside networks.

All these structured informations which defines a GIS introduce a great number of static dependences but each layer can be generally understood alone or some parts of each layer can be isolated to better understand the dependence between involved objects. Generally the applicative operators can be computed on each of these parts. In that way, we can consider classical GIS as complicated systems in the terminology proposed by Le Moigne (10). We can consider that the Geographical Data Base in association with the previous applicative operators which constitute the GIS is a closed system.

Today, the complexity of the world needs to use or to add additional functionalities on GIS. Geographical informations deal also with human-landscape interactions. The simulation of social aspects and of ecological processes seems to be more and more linked to the better understanding of the geographical data and its evolution inside its all social, geopolitic and ecological environment. To integrate these new aspects, we have to manage some complex processes like some energetic fluxes that crosses the standard GIS (see the figure 2). This complex fluxes transform the standard GIS in open systems which confer to them some properties linked to complexity. Self-organization and multi-scale organizations can emerge from these complex processes. The expected evolutions of GIS can be considered as the transition which will transform the standard complicated GIS into complex GIS.

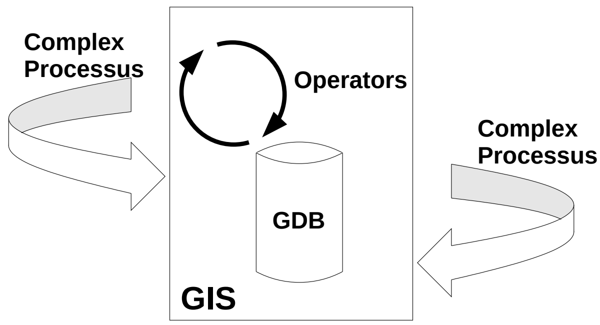

Figure 2: GIS under Complex Processus

In the following, we deal with a specific improvement on GIS which concerns its own evolution. As described in the previous section, the constant evolution of the real world induces the need to regularly update the geographical data of GIS. This evolution processus is typically a complex processus that generate some dynamical organizational processes inside GIS. The data themselves retroact on the processus during the propagation method that we will present in the next sections (7).

3 EVOLUTIVE GIS FORMALISM

We adopt the feature-based approach, where features are the fundamental concept for the representation of geographical phenomena as described in (12).

Basically, a GDB is represented in a minimal formalism, by the pair

$$(\mathcal{V},\ \mathcal{D})$$

where:

1. $\mathcal{V}$ is the set of the classes used in the GDB. Each class gathers features which have common characteristics. The set $\mathcal{V}$ gathers GDB scheme elements.

2. $\mathcal{D}$ is the definition domain of the variables of $\mathcal{V}$. It is the set of the objects of one GDB instance. The heterogeneity of objects which belong to a GDB needs

their classification for a better use. We consider 4 classes of objects which are spread over two information levels: the *geometric* level which gathers geometric primitives $\mathcal{PG}$ and the geometric objects $\mathcal{OG}$, and the *semantic* level which gathers simple semantic objects $\mathcal{OS}$ and complicated semantic objects $\mathcal{OC}$.

$$\mathcal{D} = \mathcal{PG} \cup \mathcal{OG} \cup \mathcal{OS} \cup \mathcal{OC}$$

The proposed model for a GDB which allows to evolve through updating operations must add some complementary sets which will manage some dependences between the geographical elements. So the model is composed of a quadruplet

$$(\mathcal{V},\ \mathcal{D},\ \mathcal{R},\ \mathcal{C})$$

where, in addition:

1. The connection graph over the GDB elements is based on relations between these elements. R is the set of these relations. In our object representation, these relations correspond to relations between GDB basic objects. The different kinds of relations that we consider are: composition relations $\mathcal{R}^{\mathcal{C}}$, dependence relations $\mathcal{R}^{\mathcal{D}}$ and topologic relations $\mathcal{R}^{\mathcal{T}}$.

$$\mathcal{R} = \mathcal{R}^{C} \cup \mathcal{R}^{D} \cup \mathcal{R}^{T}$$

2. $\mathcal{C}$ is the set of constraints defined between the variables of $\mathcal{V}$ and/or between variables value of $\mathcal{V}$. In our object modelization, this corresponds to constraints defined between the classes (constraints between variable) and/or between objects (constraints between values). These constraints manage the GDB evolution on many levels, so we need to classify them inside different categories corresponding to the concerned aspect of evolution. On the first level, we have classify these constraints in *structural* constraints and in *non structural* constraints.

This quadruplet corresponds to the GDB modelisation to prepare it to evolution.

Finally, to effectively manage evolution processes, we have to modelize the updating informations in accordance with the GDB conceptual model. We note $\mathcal{M}$ the updating set where basis action is the transaction and the full model for the GDB is the 5-uplet

$$(\mathcal{V},\ \mathcal{D},\ \mathcal{R},\ \mathcal{C},\ \mathcal{M})$$

.

3.1 Features representation

Objects stored in a GDB constitute different components of CGIS at different levels : geometric and semantic level.

Definition 3.1. *Given $\mathcal{PG}$ the geometric primitives set and $T = \{P,\ L,\ S\}$ the set of possible types for geometric primitives where P represent the points, L represent the lines et S represent the surfaces; We then define the function* **type** *define from $\mathcal{PG}$ to T and which gives a type to each geometric primitives.*

Definition 3.2. *A geometric object Og of $\mathcal{OG}$ is a pair (OB, OR) such that :*

- *OB is a subset of $\mathcal{PG}$ possessing more than 2 elements ;*
- *OR is a set of binary relations between pairs of geometric primitives of Og such that $OR \subset \mathcal{R}$ (the latter being the set of all the possible binary relations between objects).*

Let $\mathcal{OG}$ be the set of geometric objects.

Exemple 3.1. *The geometric object Og in figure 3 is one of the possible geometries for the object "round-about".*

$$\begin{aligned} Og &= (OB, OR) \text{ with :} \\ OB &= \{p_1, p_2, p_3, p_4, p_5\} \\ &\quad \text{where } \mathbf{type}(p_i) = L \text{ for } 1 \le i \le 5 \\ OR &= \left\{ \begin{array}{llll} \mathbf{t}(p_1,p_2), & \mathbf{t}(p_1,p_3), & \mathbf{t}(p_1,p_4), & \mathbf{t}(p_1,p_5), \\ \mathbf{t}(p_2,p_1), & \mathbf{t}(p_2,p_3), & \mathbf{t}(p_2,p_4), & \mathbf{t}(p_2,p_5), \\ \mathbf{t}(p_3,p_1), & \mathbf{t}(p_3,p_2), & \mathbf{t}(p_3,p_4), & \mathbf{t}(p_3,p_5), \\ \mathbf{t}(p_4,p_1), & \mathbf{t}(p_4,p_2), & \mathbf{t}(p_4,p_3), & \mathbf{t}(p_4,p_5), \\ \mathbf{t}(p_5,p_1), & \mathbf{t}(p_5,p_2), & \mathbf{t}(p_5,p_3), & \mathbf{t}(p_5,p_4) \end{array} \right\} \end{aligned}$$

Geometric primitives p_1, p_2, p_3, p_4, p_5 are all of line type and are linked between themselves by the topologic relation "t" (for "touch").

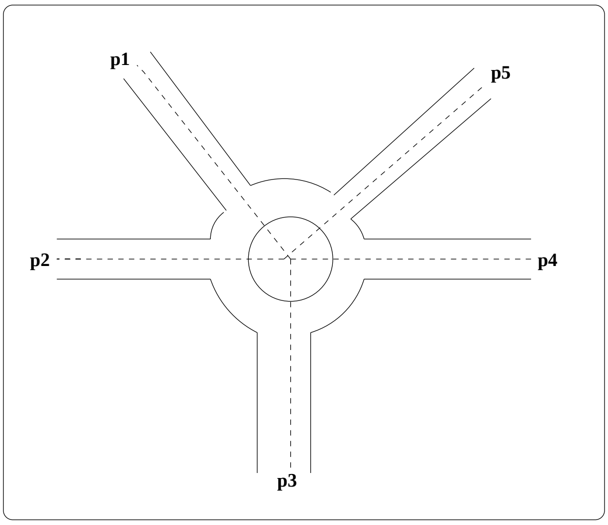

Figure 3: Round-about object geometric representation.

Definition 3.3. *Let $\mathcal{OS}$ be the set of simple objects and $\mathcal{ATT}$, be the set of descriptive attributes of the simple objects.*

A simple semantic object Os of $\mathcal{OS}$ is a pair (p, ATT) such that :

- *p is a geometric primitive : $p \in \mathcal{PG}$;*
- *ATT is a non-empty subset of $\mathcal{ATT}$: $ATT \in \wp(\mathcal{ATT}) - \{\phi\}$, where $\wp(\mathcal{ATT})$ stands for the set of subsets of $\mathcal{ATT}$.*

Definition 3.4. *A complex object Oc of $\mathcal{OC}$ is a pair (OBS, ATT) such that :*

- *ATT is a non-empty subset of $\mathcal{ATT}$: $ATT \in \wp(\mathcal{ATT}) - \{\phi\}$;*
- *OBS is a non-empty subset of simple semantic objects : $OBS \in \wp(\mathcal{OS}) - \{\phi\}$;*
- *$\forall Os \in OBS,\ \exists\, R^C \in \mathcal{R}^C$ tel que $R^C(Oc,\ Os)$.*

Let $\mathcal{OC}$ be the set of complex objects.

3.2 Relations representation

Since objects are classified in two different levels, only objects of the same level can interact. The interaction network over these objects is based on relations between these components. These relations are also classified in two levels : semantic relations and topological relations.

1. *Semantic relations*: they are essential for the constraints propagation description. They are composed of *composition relations*, $\mathcal{R}^{\mathcal{C}}$, which allow to describe aggregation of some objects and *dependence relations*, $\mathcal{R}^{\mathcal{D}}$, which describe that the modification of one object can lead to the modification of other ones;

   Definition 3.5. *One calls composition relation of $R^C(O, O')$ between O, a complex semantic object and O' a simple semantic object, the relation which expresses the fact that "O is composed of O'".*

   Definition 3.6. *One calls dependence relation $R^D(O, O')$ between O and O', the relation for which a modification of the object O (called master object), can alter the semantic attributes of the object O' (called dependent).*

2. *Topological relations*: they describe the type of topological connection between objects. We proposed to use the 9-intersection from Egenhofer and Herring (5). In this model, we use a topology which consists to define for each object p_i, the inset noted p_i°, the closure set noted $\overline{p_i}$, the outline set noted ∂p_i and the exterior set noted p_i^-. This model can be represented by the matrix formulation

$$\begin{pmatrix} \mathrm{P}(\partial p_k \cap \partial p_l) & \mathrm{P}(\partial p_k \cap p_l^\circ) & \mathrm{P}(\partial p_k \cap p_l^-) \\ \mathrm{P}(p_k^\circ \cap \partial p_l) & \mathrm{P}(p_k^\circ \cap p_k^\circ) & \mathrm{P}(p_k^\circ \cap p_l^-) \\ \mathrm{P}(p_k^- \cap \partial p_l) & \mathrm{P}(p_k^- \cap p_l^\circ) & \mathrm{P}(p_k^- \cap p_k^-) \end{pmatrix}$$

   Figure 4 shows some specific situations that these matrix formulation allow to describe.

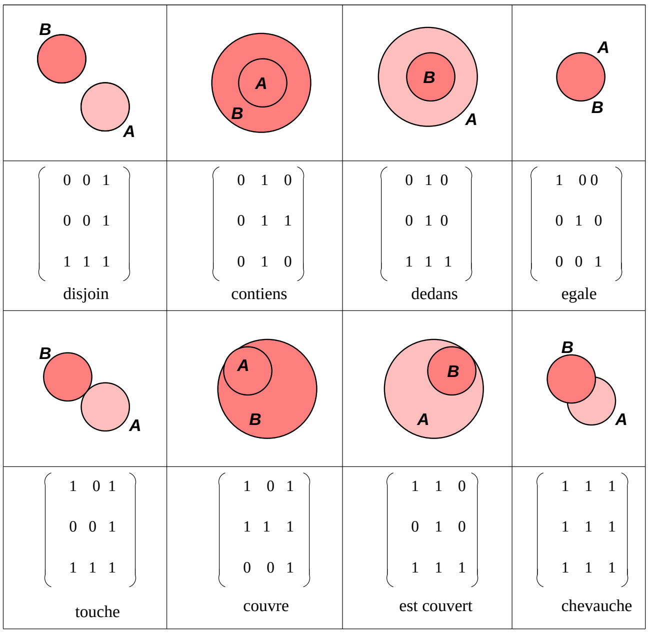

Figure 4: 9-intersection topological model

3.3 Constraints representation

We represent the following constraints: structural, temporal, spatial and semantic ones. We define also for each constraint its importance which means that some of them have to be always satisfied and others can be raised, using exception processes. We formally define each constraint between two objects as a 5-uple composed of (i) the first object class, (ii) the second object class, (iii) the relation associated to the constraint, (iv) its importance and (v) an exception field which allow to raise some constraints.

Definition 3.7. *A geographical integrity constraint, called "G-constraint", is an integrity constraint defined over semantic objects, characterized by its severity, its category, its range and its expression. It is defined by a 5-tuple :*

$$G - Contrainte = (ID_c, S_c, C_c, P_c, Expr_c)$$

where ID_c uniquely qualifies each G-constraint, the severity level S_c defines the type of conflict which can be induced by the violation the G-constraint, the category C_c denotes the application domain of the G-constraint and its range P_c qualifies the elements on which it is applied.The expression $Expr_c$ of the G-constraint depend on its category and its range.

Exemple 3.2. *Let $c1$ be the relative G-constraint which points out that a segment of road never crosses a building.*

In our language this G-constraint is defined as follows :

$$\begin{aligned}(ID_c &= c1,\\ S_c &= relative,\\ C_c &= topologique,\\ P_c &= interclasse,\\ Expr_c &= expr1)\end{aligned}$$

$$\begin{aligned}expr1 = \ & (TRoute : Os_1,\\ & Batiment : Os_2,\\ & INTERSECT, interdit, \phi).\end{aligned}$$

3.4 Formalization of the updating flow

Evolution of a geographical data base often reflects the evolution of the nominal ground it is supposed to modelize. This induces, in the base, integration of a set of update operations which modify, in turn, components of the system (its objects). The alteration of certain components can affect other components in a recursive way. According to the type of the operations under consideration, their running can make the geographical data base swell, shrink or change in content without altering the volume.

The set of the operations and of the involved objects is the set of *updating informations* or, in other words, the updating flux.

The updating informations proposed in the model is based on 8 *complex operations.*

Definition 3.8. *A complex operation is an operation which applies over simple or complex semantic objects and which can split up into several simple operations. Let op_co be a complex operation,* $op\_co \in \{Ccre, Csup, Scis, Fus, Agg, Cgeom, Cdesc, Stb\}$ *such that*

$$\begin{aligned}Ccre &= Creation\ complexe\\ Csup &= Suppression\ complexe\\ Scis &= Scission\\ Fus &= Fusion\\ Agg &= Aggregation\\ Cgeom &= Modification\ geometrique\\ Cdesc &= Changement\ descriptif\ complexe\\ Stb &= Stabilite.\end{aligned}$$

which are complex creation, complex suppression, splitting, fusion, aggregation, geometric modification, complexe descriptive modification, stability. We have shown (9) that each complex operation can be decomposed as a sequence of some of the 4 canonical operations: creation, suppression, descriptive modification and identity.

Definition 3.9. *We call canonical operation every operation which cannot be split up in terms of other operations. Let op_ca be a canonical operation,* $op\_ca \in \{Cre, Sup, Desc, ID\}$ *such that*

$$\begin{aligned}Cre &= Creation\\ Sup &= Suppression\\ Desc &= Changement\ descriptif\\ ID &= Identite.\end{aligned}$$

To do an updating, one must define an execution order for the involved canonical operations. This leads us to the definition of a sequence.

Definition 3.10. *A sequence is a totally ordered set of canonical operations which correspond to a given complex operation.*

Finally the basic updating unity is the *transaction* which is a set of *sequences* of canonical operations.

4 DYNAMIC INTERACTION NETWORK

The integration of the updating flow in the geographical data base starts the dynamics of the system evolution. Let's recall that updating flow is structured as a set of transactions, each one is a set of canonical operations sequences. So, each canonical operation, applied on an object, activates some falls of updating operations to apply on other objects. Although the starting operation is known, since it is a membership of the input updating flow, the other consequent operations, called influence operations, are not known. Objects to which these operations are applied, called influenced objects, are not either known.

Using the previous formalism, we will show in this section (i) how influenced objects are defined, (ii) how influence operations are computed and (iii) how these objects interact. We will show that all the computation can be summarized inside a Table of Influences that cross the connection graph to build an interaction network.

4.1 Topological influence area and connection graph

We consider the target semantic object O_c to be updated. We define the *Topological Influence Area* as the following:

Definition 4.1. *We consider O_c a target object to be updated from a GDB. Its* Topological Influence area *that we note as $\mathcal{Z}^{it}(Os)$, collects all the GDB objects which are inside a neighbourhood of O_c and which are linked to 0_c.*

Exemple 4.1. *Figure 5 shows the influence area of the target object ID 9814 which is a camping. The table 1 contains a part of the set of the ID objects which belong to his influence area. For each ID object, its corresponding class and the topological relation with the target object are given.*

We represent the topological influence area by a connection graph which connects the objects linked by a topological relation.

Exemple 4.2. *Figure 6 shows some element of the connection graph corresponding to some relation from the target object ID 9814, based on the table 1.*

ID	CLASS	RELATION
7130	BATIMQCQ	contains
7135	BATIMQCQ	contains
7134	BATIMQCQ	contains
3640	ROUTE_TR	borders
2264	ROUTE_TR	borders
452	CARREFOURNA	touchs
453	CARREFOURNA	touchs
...	...	...

Table 1: *Topological influence area from object ID 9814*

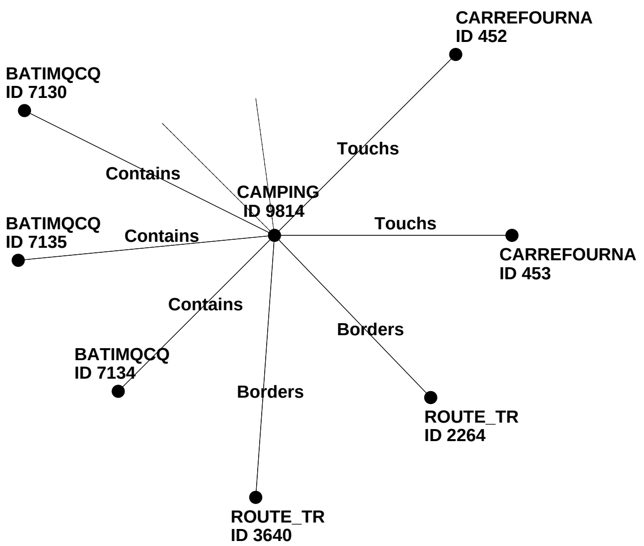

Figure 6: Connection graph (extract from object ID 9814)

4.2 Table of influences

Using the canonical decomposition of updating informations, we can define a *table of topological influences* which allows to obtain, from an operation applied to an specific object, what are the effects on the other objects in its neighbourhood. Corresponding to the 3 geometric primitives and the 4 canonical operations, we obtain a finite table which can describe all the situations.

In the example corresponding to one line of the table of topological influences shown in the table 2, the situation is the suppression of the area object p which constraints

p	p'	$Op(p)$	$R^T(p, p')$	Influence
Area	Area	Suppress.	In	{ID, Suppress.}

Table 2: One line in the table of topological influences

another area object p' and that can lead to one of the following operations for this second object, that is to remove it or not. To know what is the resulting operation, we need to explore the semantic influence which is itself managed by another *table of semantic influences*.

4.3 From Connection Graph to Interaction Network

Because of the canonical decomposition, all the updating processes are summarized in the influence table and the application of each line of this table can be considered as a rule to be applied to the connected graph which describes the objects of the GIS and the relations between them.

Using the influence table, we apply some rules and activate some interactions between GIS objects relatively to the updating operation that we presently manage. In that way, we build an interactive network that is developed dynamically during the processus (2). The new elements aggregate to this interactive network will generate new processes. The complete algorithmic description is made in the following section.

We make some comparisons between the processus used here with the one usually use with cellular automata. These comparisons are summarized in figure 7. The connection graph which represent the GIS objects in relation can be compared to the cellular automon mesh. The two describe potential connection. In some way, we can consider the mesh and the graph as dual representation. The rules for cellular automata and the influence table applications make activated interactions that are represented in the part (b) of the figure.

5 PROPAGATION AND CONSISTENCY

Propagate the effect of an updating operation in the geographical data base means to execute the starting operation and all the influence operations which result from it without altering its consistency. This is translated, in our system, by the installation of the interaction network built from the connection graph and the table of influences. Once the interaction network is generated, it should be checked that it does not have inconsistency (8).

The inconsistency checking mecanism is based on a general incremental processus. The incremental proces-

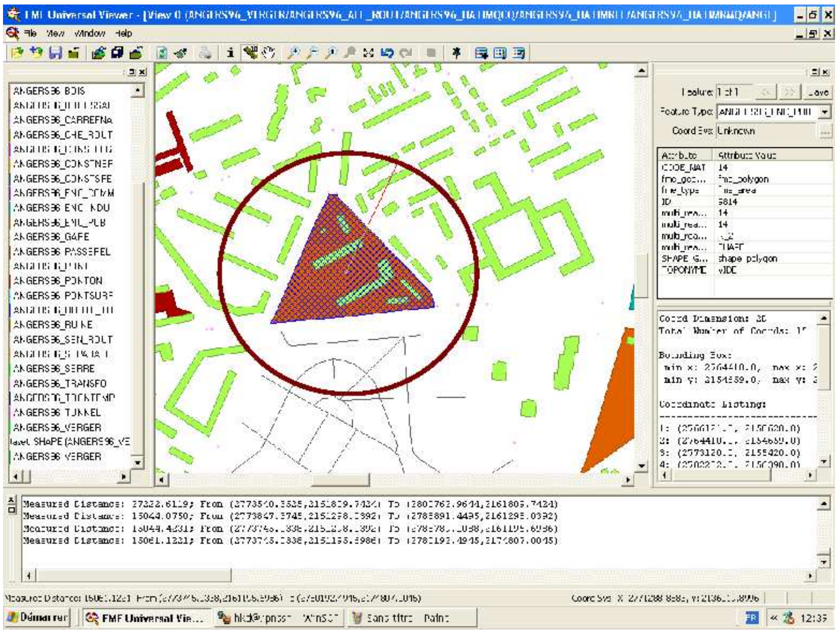

Figure 5: Topological influence area from object ID 9814

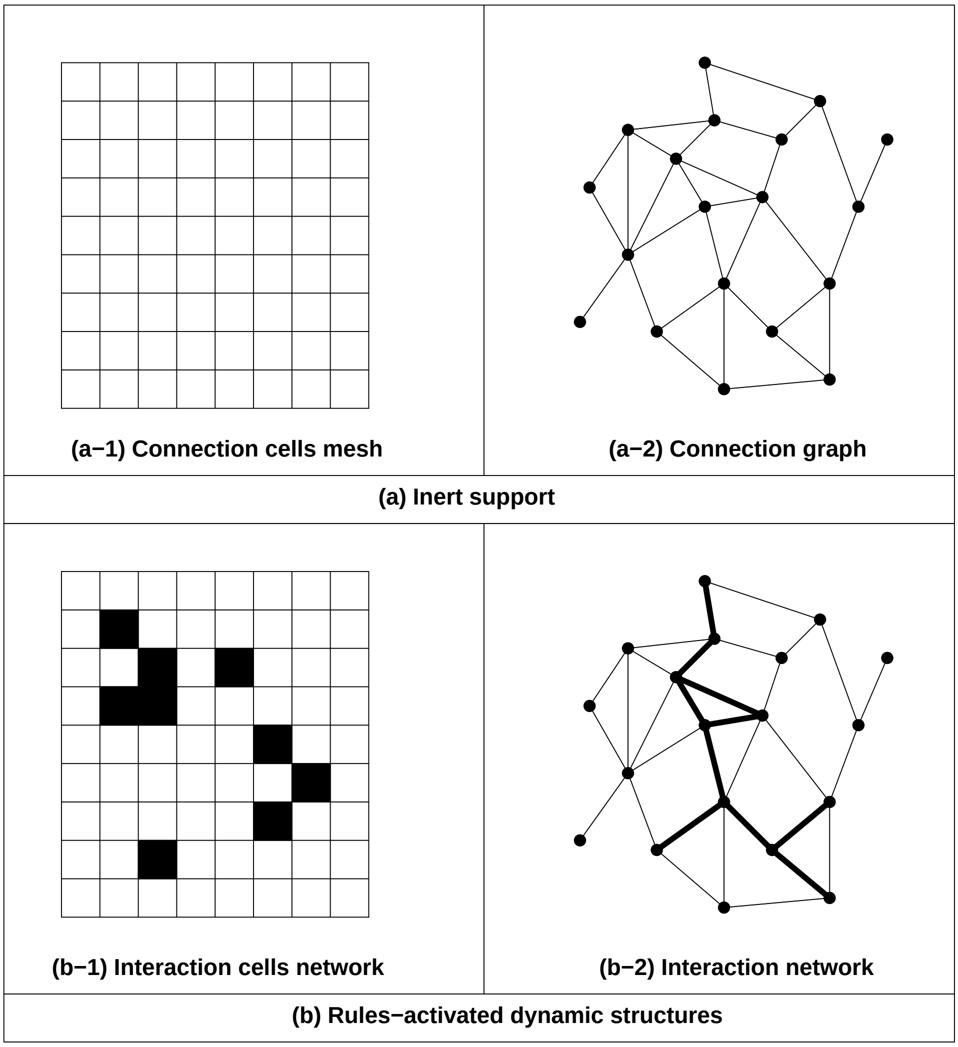

Figure 7: From cellular automata to interaction networks

sus consists in decomposing each elementary updating operation in 2 parts: the first is the implementation of a canonical operation and the second is the checking of the consistency maintenance. If this checking is free from conflicts, the next canonical operation on the network path is visited and the incremental processus continues.

If we consider an object O_c and an associated updating operation, *op*, the mecanism of propagation is applied in a local zone centered on the object O_c, called working zone from where we extract the set of other objects which may be under the influence of the first one. The propagating mechanism is recursif but we limit the exploration inside the working zone. A full algorithm description of this method is given in (9).

6 EMERGENT PROPERTY

The local propagation allows to avoid to explore the whole geographic data base. Now, we need to build a processus that will compute the adapted working zone which permits to tell whether the local consistency maintenance is enough to insure the global consistency maintenance. For that purpose we propose an algorithm that we called *dilatation method* and that consist to progressively increase the working area like a new disk centered on the initial object O_c and which radius is augmented step by step with the value p until that a further increase will not compute new objects involved in the propagation processus. That leads us to define this computed area as the *stability area* associated to the object O_c.

To prove that the local consistency maintenance can be sufficient for the global consistency maintenance, we had to define some hypothesis about the regularity of the objects repartition. The properties given in the following are prove in (9).

Definition 6.1. *A finite set of planar points is called p-dense if the Delaunay triangulation over all the set of points has no edges longer than p.*

Property 6.1. *If the influence area of the point O_c is p-dense then the dilatation method with a step equal to p computed from O_c give the stability area of this point*

Property 6.2. *The local consistency over the stability area for an object O_c will insure the consistency of the whole Data Base.*

This last emergent property allows us to define a subset of objects from the GDB and be able to predict that the behavior of these objects is himself the behavior of all objects of the GDB vis-a-vis to a flow of update.

This first theoretical result allows us to implement in an efficient way, the whole updating system, with the postulate that the natural geographical data follows this hypothesis of regular distribution, using an adapted step of resolution for the dilatation method.

7 IMPLEMENTATION AND EXPERIMENTS

The whole system has been originally developed in the COGIT laboratory where it has been implemented. This system is in operational practice and has been connected to the framework OXYGENE (1) of this laboratory. A methodology for its validation has been developed and has proved that the mechanisms are efficient, even if some rejection can be avoid with a better scheduling. The genetic algorithm engine is still under development and validation and it will improve the quality of the whole system.

An experiment has been developed on the IGN GDB concerning the Angers French town zone. Using some matching technique between two of these GDB from 1994 and 1996, we have built a set of updating informations. A *precision* indicator is computed as the rate between the right decisions and all the decisions taken by the EVOLA system. From a specific experiment based on 30 canonical operations, we have obtained a precision indicator equal to 0.948 which is sufficient to validate the whole processus. A detailed description about validation can be find in (9).

8 CONCLUSION

This paper describes a consistent updating processus over a Geographical Data Base (GDB) as a complex operation concerning Geographic Information Systems (GIS). Our purpose is to explain where the complexity occurs during the processus, The formalism proposed for the geographical information description is based on objects. To manage the updating, we have to define semantic and topological relations which allow to define the influence area associated with each object. These relations between objects are represented with a connection graph. Moreover, we have to manage some constraints which deal with consistency maintenance of the whole data base ; a specific language is proposed for that purpose. Even if the connection graph is important on a whole geographic map, the previous system to describe GIS is complicated in the sense that we can manage it correctly by successive splitting and application of basic operators.

The updating processus is then defined over the GIS as a complex flux that make involved the GIS. This processus implements a propagation method which consists to act by updating on GDB objects and these objects propagate the updating operators using an influence table and so retro-acts on the whole system and processus. In that sense, the updating processus crosses the GIS like an evolutive organizational flux which transform the GIS from a complicated system to a complex system. The basis of the updating is the use of influences tables which summarize all the canonical operators needed. The application of this influence table can be compared with the rule-based processus which make involved a cellular automaton.

Finally we show how the updating processus, as a complex flux over GIS, can lead to obtain an emergent property. This property allows to obtain the global consistency maintenance of the whole GDB from only local consistency maintenance. We implement a dilatation method that can be considered as a way to obtain a self-organization concerning the updating problem.

The complex decomposition and description of the work presented in this paper allows us to build conceptual models over GIS which can be used to manage some others kinds of complex processes. We can adapt this proposed method for updating flux to other kinds of complex processes flux. In these complex processes, we can consider the human aspects of geography which deal with social, geopolitic and ecological purposes (6). The proposed methods used here can give conceptual approaches to manage such major developments which give all the power in the use of GIS in our present complex world, to better understand and analyze it.

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